JPRS: 3410

21 June 1960

THE POSSIBILITY OF USING AS A PHOTOGRAMMETRIC BASE THE 1:25,000 MAP FOR PHOTOGRAMMETRIC MAPPING AT SCALES OF 1:10,000 AND 1:5,000

- Czechoslovakia -

by Vaclav Pichlik

U. S. JOINT PUBLICATIONS RESEARCH SERVICE
205 EAST 42nd STREET, SUITE 300
NEW YORK 17, N.Y.

F O R E W O R D

This publication was prepared under contract by the UNITED STATES JOINT PUBLICATIONS RESEARCH SERVICE, a federal government organization established to service the translation and research needs of the various government departments.

JPRS: 3410

CSO: 3664-D

THE POSSIBILITY OF USING AS A PHOTOGRAMMETRIC BASE THE 1:25,000 MAP FOR PHOTOGRAMMETRIC MAPPING AT SCALES OF 1:10,000 AND 1:5,000

[Following is a translation of an article by Vaclav Pichlik in the Czechoslovak periodical Geodeticky a kartograficky obzor (Geodetic and Cartographic Review), No 12, December 1959, Prague, pages 221-224.]

(Results of experimental work using as a photogrammetric base the 1:25,000 map and a universal machine of the first order to determine the matching points on the photograph of the 1:10,000 map.)

In Czechoslovakia, as soon as mapping at the 1:25,000 scale was completed, work started on topographic mapping at the 1:10,000 scale and in some localities also at the 1:5,000 scale.

I. Present mapping methods

The sequence of mapping work at given scales makes it possible to use as a photogrammetric base the 1:25,000 map in making maps at the indicated larger scales. This possibility was demonstrated practically in mapping work in which the combined method was used at the 1:10,000 scale and in some cases also at the 1:5,000 scale.

Experimental work, in which the photographs of the 1:25,000 map were used in mapping by the combined method at the 1:10,000 and 1:5,000 scales, was carried out on the basis of the following considerations:

1. The aerial photographs accumulated in photogrammetric mapping at the 1:25,000 scale can be considered to a great extent as true photographs of the existing objects of measurement as regards topographic mapping at the 1:10,000 and 1:5,000 scales, because these objects of measurement change only in certain limited localities or to a small extent.

2. The aerial photographs for the 1:25,000 map were made at the 1:18,000 to 1:23,000 scales. Therefore it is possible to transcribe them in the 1:10,000 scale, and in some cases also in the 1:5,000 scale.

3. The capacity of the negative material to distinguish objects is 0.025 mm. This causes a lack of sharpness in photographs at 0.1 mm only when the enlargement is quadruple. Therefore the lacking sharpness is less than that seen by the evaluator when he evaluates the sharpness on the universal instrument. When the photographs described above were made, the total enlargement factor for a photoplan at the 1:10,000 scale was always smaller.

4. It is possible to assume that the photographic quality of the photographs used in mapping at the 1:25,000 scale was generally the same. Since the mapping of most of the territory was made by the universal method, the photographic quality of these photographs should not be an obstacle as regards use of the combined method.

The results of control measurement in the field as regards photoplans made at the 1:10,000 and 1:5,000 scales from photographs prepared for the 1:25,000 map proved that the procedure used is feasible and economical.

In practice, sometimes photoplans are requested in the 1:10,000 and 1:5,000 scales from photographs made during a new observation flight. These instances concern mostly those localities where the objects of measurement do not appear on the photographs made for the 1:25,000 map.

II. Other possible uses

I believe that when we apply the universal instrument, it will be convenient to use as a photogrammetric base the 1:25,000 map for the following purposes:

a) to determine the position coordinates of the matching points in evaluating the photographs taken on a new survey flight by using the universal method at the 1:10,000 scale. The elevation coordinates of these matching points can be used at the same time for making a rough check of elevations;

b) to determine the matching points in establishing the scale of the model, if it is not possible to determine the matching points in the corners of pairs of photographs in evaluating the 1:10,000 map through the photographs taken on a new observation flight;

c) to determine the coordinates of the matching points on photographs taken on a new observation flight in making a photoplan or evaluating the positions on a universal instrument at the 1:10,000 scale, and in some cases also at the 1:5,000 scale. The accuracy of the elevation of the specified matching points is sufficient for redrawing or evaluating the positions on a map.

The following were prerequisite for the use as a photogrammetric base of the 1:25,000 map in mapping work at the 1:10,000 and 1:5,000 scales:

1) According to an analysis of the accuracy of the coordinates of matching points used in making up the 1:25,000 map, the average position error of such points was found to be ± 0.25 to ± 0.50 m, and the average elevation error ± 0.25 m.

2) The coordinates of these points were checked previously during an evaluation at the 1:25,000 scale, and any gross errors of calculations or determinations were corrected.

3) Assuming that the accuracy of nonsignalized points determined photogrammetrically on universal instruments is about 0.04 mm at the scale of the photograph, it is possible to use 1:18,000 photographs in determining photogrammetrically the matching points with an average position error of ±0.70 m; and 1:23,000 photographs with an average position error of about ±0.90 m.

4) Assuming that the accuracy of photogrammetric determination of the elevation of a point is about 0.3 o/oo of the flight altitude, it is possible to determine the elevation of a point from a 1:18,000 photograph with an average error of ±1.15 m; and from a 1:23,000 photograph with an average error of ±1.44 m.

5) In order to concentrate the number of available points, the method is sometimes used in which the coordinates of the matching points of larger-scale photographs are determined photogrammetrically from smaller-scale photographs with measured matching points.

6) Due to errors made in determining the coordinates of the matching points for the 1:25,000 map, for which the matching points were determined photogrammetrically by using 1:18,000 photographs, the average position error of the determined points may reach ±0.85 m, and the average elevation error ±1.20 m. Using 1:23,000 photographs, the average position error of the determined points may reach ±1.05 m, and the average elevation error ±1.46 m.

7) These values agree with paragraph 39 of the "Directives for Photogrammetric Work at the 1:10,000 and 1:5,000 Scales," Part II, according to which the differences of the positions of points determined in the upper and lower row must not be greater than 0.3 mm, and the differences of the double determination of altitudes (from the upper and lower row) must not be greater than 1.5 m.

If, according to directive F2 of paragraph 39, we compare the assumed errors in determining the matching points from the photographs for the 1:25,000 map with the admissible errors in determining the matching points for the 1:10,000 map, we can see the possibility of using as a photogrammetric base the 1:25,000 map to determine the matching points of photographs for the 1:10,000 map -- in some case also for the 1:5,000 map -- thus decreasing substantially the time used in mapping work.

Decisive as regards the above should be the results of practical verification of the assumed accuracy in the determination of the coordinates of the matching points using a given photogrammetric base, and the possibility of identifying the matching points on photographs for the 1:25,000 map and those for the 1:10,000 map. Since there will always be a comparatively large difference in the time when the photographs were taken, this identification will often be rather difficult. The difference in time and the resulting limited possibility of

identification will probably be more serious in using as the photogrammetric base the 1:25,000 map to check the geodetically-determined matching points of the 1:10,000 map than in selecting and determining them according to photographs for the 1:25,000 map. The advantage of the assumed method of using as the photogrammetric base the 1:25,000 map seems to be that use is made of matching points the coordinates of which have been verified and corrected during the photogrammetric evaluation of the 1:25,000 map, and also that the photogrammetric base of the 1:25,000 map -- and therefore also the coordinates of the matching points -- will again be verified according to the proposed procedure at the time we calculate the transformation keys.

III. Procedure for determining the matching points

If we apply the procedure suggested above, we should follow the following steps:

1. On photographs for the 1:10,000 map we should mark by circles the area of the projected points and also mark these areas on the photographs for the 1:25,000 map, or on enlargements of them, approximately at the scale of photographs for the 1:10,000 map.

2. In the circled areas on the photographs of both scales we should find easily-identifiable objects for the selection of matching points and more accurate determination of the position of the projected matching points by means of appropriate markings (pins or symbols). The identification should be done either by direct comparison of the photographs or by stereoscopic observation of the photographs for the 1:10,000 map and enlarged photographs for the 1:25,000 map.

If it is not possible to identify the matching points ... photographs in the projected areas, we should then determine ... or more matching points with a view to determining and controlling the scale of the model. The criteria for locating matching points on the pairs of photographs make it possible to determine such points even when it is not possible to identify the matching points on both photographs for purposes of comparison of altitudes. It will be advantageous to mark a larger number of matching and controlling points than is necessary for evaluating or determining the scale of the photographs or of copies of them. By determining a larger number of points, we increase only slightly the time consumed in evaluating and computing the material; but, on the other hand, we also have a sufficiently accurate check on the accuracy of the copy when the photographs have to be recopied.

3. We should evaluate the machine coordinates and possibly also the altitudes of the projected matching points for the 1:10,000 map on universal machines of the first order.

To get absolute orientation of the photographs, we should mark the matching points of the 1:25,000 map, given according to the geodetic coordinates at the scale of 1:10,000. The best way to do this is on a sheet of clean paper. Then we should read the data to get an absolute orientation, then the machine coordinates in two rows, and then record the coordinates on suitable forms (for example, Geodesy 102 and 103).

In order to evaluate the accuracy of the determined points, it is useful to select a larger number of points than is necessary for photogrammetric evaluation, and to select them in the area of a treble longitudinal fold and in the area of transversal folds. Independent determination of the coordinates of the matching points for the 1:10,000 map makes it possible to evaluate the accuracy of the determination of the coordinates.

In order to facilitate accurate identification of the specified matching points for the purpose of evaluating the photographs of the 1:10,000 map, it is useful to estimate the location of new matching or controlling points, when reading the machine coordinates of these points, by comparing them to the nearest configuration, which is actually the topography of the matching points for the 1:10,000 map.

4. On the basis of the given geodetic coordinates, we should make an arithmetical transformation of the machine coordinates. For the transformation key, we recommend using all the matching points represented in the pair of photographs. Thus, assuming that the reading of the photogrammetric coordinates is equally accurate, we should verify the accuracy of the determination of the given matching points. For purposes of transformation, we can again use the Geodesy 103 forms.

IV. Assumed advantages of the proposal

1. If we are required to prepare a map in the 1:10,000 scale by the combined method, or a photoplan for other purposes on the basis of the photographs of a new survey flight, and if it is possible to identify the necessary matching points on the photographs for the 1:10,000 map and for the 1:25,000 map, we can determine both the positions and the elevations of these points from the photographs for the 1:25,000 map without any geodetic work in the field.

When covering an area of higher altitude, or when it is impossible to identify the matching points for the purpose of recopying every second photograph, it is sometimes useful to place the matching points in the center of the longitudinal double fold and to recopy every photograph.

2. When we use the universal method, the procedure indicated above can be used only under the conditions and to the extents indicated below:

a) If, in evaluating the 1:10,000 map, it is possible to identify the matching points in the projected areas both on photographs for the 1:10,000 map and on those for the 1:25,000 map, then, after the transformation of photogrammetric coordinates into geodetic coordinates, the position coordinates can be determined with sufficient accuracy. Their photogrammetrically-determined elevations above sea level can probably be used only for a rough check of the elevations above sea level determined by field measurements.

The elevations above sea level of the determined matching points can then be determined according to column (3) of paragraph 50 of Instruction M-1, i.e., trigonometrically by computing the distances from the map base, or by technical leveling, or possibly by means of tacheometric chains.

b) If it is possible to identify only the matching points placed on a pair of photographs of those for the 1:10,000 map and on photographs for the 1:25,000 map, these being used only for determining and controlling the scale of the model, then it suffices to measure the matching points for horizontal measurement of the model by means of the universal instrument in determining elevation (technical leveling or tacheometric chains). When measuring elevations above sea level, it is useful in this case to run the leveling or tacheometric chains through the centers of the transversal folds and approximately along the connecting lines of the principal points of the individual chains.

If we plan to measure elevations above sea level on individual sheets, then we must measure five chains for one map sheet at the 1:10,000 scale with one photograph at the 1:18,000 scale. Assuming that each chain will be longer by 30% than the longitudinal dimension of the map sheet, it will be necessary to measure 30 km of a chain on a photograph at the 1:18,000 scale and 7 chains 42 km long on a photograph at the 1:13,000 scale.

In selecting the presentations or tacheometric positions on the identified points of the photographs, it will be possible to measure about 100 control points on a map sheet along a distance of 30 km for the purpose of reviewing the photogrammetric evaluation, and about 150 points along a distance of 42 km. At the same time, we shall also use the verified matching points measured for mapping at the 1:25,000 scale. There will be 12-17 matching points from photogrammetric mapping at the 1:25,000 scale for every sheet of the 1:10,000 map.

Assuming that the distances of the leveling points will be only 40 m, or the sides of an elevation tacheometric chain about 250 m, the suggested method will save approximately 40% of the time necessary to determine the matching points by the present geodetic method.

The time saved in mapping work by the suggested method of determining the matching points could be increased even more by measuring the elevation control points on the sides during technical leveling, or by measuring the area of tacheometric chains. Thus, by increasing only slightly the time spent in measuring the chain, we could measure a large number of points for the purpose of controlling the photogrammetric evaluation. Time would also be saved because with the proposed method of determining the matching points it would not be necessary to renew the signals of a given geodetic network. By using our method of determining the matching points for the purpose of determining and controlling the scale of the evaluated model, we do not need to determine the location of the matching points in order to evaluate their elevation. A similar method is used in the Soviet Union to determine the position of matching points by means of radial triangulation.

TABLE 1 (Left side)

Point number	Set of 2 photographs	Photogrammetrically determined elevation Z	Average of photogrammetrically determined elevations Z_s	Deviation of photogrammetric elevations from the average 0_z +	−	Photogrammetric coordinates transformed into geodetic coordinates Y	X	Average of transformed photogrammetric coordinates Y_s	X_s
3	8074-75	400.00			0.12	478,996.82	534,787.22		
	8088-89	400.05	399.88		0.17	478,997.91	534,787.24	478,997.39	534,787.30
	8087-88	399.60		0.28		478,997.43	534,787.43		
4	8074-75	412.85	411.65		1.20	479,499.97	535,285.43	479,501.91	535,285.39
	8075-76	410.45		1.20		479,503.85	535,285.35		
6	8074-75	435.05	434.75		0.30	479,537.71	535,987.72	479,538.03	535,987.52
	8075-76	434.45		0.30		479,538.36	535,987.33		
10	8076-77	451.75	451.87	0.12		481,620.90	534,751.35	481,621.10	534,751.46
	8089-90	452.00			0.13	481,621.29	534,751.57		
11	8076-77	475.40	475.32		0.08	482,115.61	534,945.58	482,116.43	534,945.48
	8089-90	475.25		0.07		482,117.25	534,945.38		
12	8075-76	437.60			0.65	480,537.14	534,925.62		
	8088-89	436.20	436.95	0.75		480,535.51	534,924.85	480,536.24	534,925.16
	8089-90	437.05			0.10	480,536.08	534,925.00		
13	8075-76	419.60	419.85		0.25	479,980.42	534,689.46	479,980.71	534,689.98
	8088-89	420.10		0.25		479,981.00	534,690.51		

TABLE 1 (Left side, continued)

14	8074-75	361.75		0.03		479,185.08	534,661.33	
	8087-88	361.70	361.78	0.08		479,185.93	534,663.49	479,185.68 534,662.62
	8088-89	361.90			0.12	479,186.02	534,663.03	
15	8088-89	414.90			0.20	478,901,73	533,419.57	
	8087-88	414.50	414.70	0.20		478,901.70	533,420.18	478,901.72 533,419.87
16	8088-89	421.10			0.63	479,114.20	532,663.12	
	8087-88	419.85	420.47	0.62		479,113.91	532,664.22	479,114.05 532,663.67
17	8088-89	380.45			0.18	479,130.33	532,069.32	
	8087-88	380.10	380.27	0.17		479,131.83	532,067.50	479,131.08 532,068.41
20	8087-88	347.45		0.25		479,084.91	531,530.62	
	8088-89	347.95	347.70		0.25	479,084.62	531,528.83	479,084.76 531,529.72
24	8088-89	361.75			0.07	480,458.76	532,104.07	
	8089-90	361.60	361.68	0.08		480,457.96	532,103.37	480,458.36 532,103.72
25	8088-89	365.75		0.05		480,655.63	532,729.70	
	8089-90	365.85	365.80		0.05	480,655.09	532,729.60	480,655.36 532,729.65
26	8088-89	384.40		0.60		480,684.48	533,575.01	
	8089-90	385.60	385.00		0.60	480,684.35	533,575.02	480,684.42 533,575.02
27	8088-89	398.95			0.13	480,911.11	534,273.34	
	8089-90	398.70	398.82	0.12		480,912.13	534,274.21	480,911.62 534,273.77
28	8088-89	388.90			0.03	481,039.33	532,476.81	
	8089-90	388.85	388.87	0.02		481,038.79	532,477.86	481,039.06 532,477.33

FOR OFFICIAL USE ONLY

TABLE I (Right side)

Point number	Deviation of the transformed coordinates from the average O_y +	O_y −	O_x +	O_x −	Position deviation
3	0.57		0.08		0.58
		0.52	0.06		0.52
		0.04		0.13	0.14
4	1.94			0.04	1.94
		1.94	0.04		1.94
6	0.32			0.20	0.37
		0.33	0.19		0.38
10	0.20		0.11		0.23
		0.19		0.11	0.22
11	0.82			0.10	0.83
		0.82	0.10		0.83
		0.90		0.46	1.01
12	0.73		0.31		0.79
	0.16		0.16		0.23
13	0.29		0.52		0.59
		0.29		0.53	0.59

TABLE I (Right side, continued)

14	0.60		1.29		1.43
		0.25		0.87	0.91
		0.34		0.41	0.53
15		0.01	0.30		0.30
	0.02			0.31	0.31
16		0.15	0.55		0.57
	0.14			0.55	0.57
17	0.75			0.91	1.19
		0.75	0.91		1.19
20		0.15		0.90	0.91
	0.14		0.89		0.90
24		0.40		0.35	0.53
	0.40		0.35		0.53
25		0.27		0.05	0.27
	0.27		0.05		0.27
26		0.06	0.01		0.06
	0.07		0.00		0.07
27	0.51		0.43		0.67
		0.51		0.43	0.67
28		0.27	0.52		0.59
	0.27			0.53	0.59

(According to this table, the coordinates of 17 points were determined by evaluating six pairs of photographs; the coordinates of three of these points were determined as the averages of three independent evaluations, and the coordinates of 14 points were determined as the averages of two independent evaluations. The mean elevation deviation of the determined 17 points is +0.42 m and the mean position deviation ±0.78 m.

(Large-scale experiments were carried out in Poland in identifying matching points in the open country on the basis of aerial photographs made at various scales. According to Dmochowski, the accuracy of this identification is not affected by the scale of the photograph, and the mean position error of identification is ±0.15 to ±0.20 m.)

Another advantage of the proposed method will probably be apparent in that the photogrammetric method of determining matching points affords a better selection of clearly identifiable matching and controlling points.

Of course the most difficult operation of the proposed method will be the identification of the same points on photographs for 1:10,000 and 1:25,000 maps.

V. Practical test of the method

The method, described above, of using as a photogrammetric base the 1:25,000 map was accepted by the USGK [Ustredni Svaz Geodetu a Kartografu -- Central Union of Geodesists and Cartographers] as the solution of assignment No 2 in the USGK competition of innovators and inventors for the period 1958/1959: revision of the correct method of determining matching points. The method was transmitted to the Geodetic and Topographic Institute in Prague for practical verification.

The verification was made on one sheet of the 1:10,000 map. However, the matching points for this map sheet were measured by the classic method on photographs for the 1:10,000 map. Consequently the proposed working procedure could not be followed entirely. As a result, the possibility of a clear identification of a sufficiently large number of matching points on the photographs from both aerial surveys was limited.

Tests were carried out by means of the Wild A7 autograph by comrades V. Klimova and J. Janovska in the photogrammetric operational unit of the GTU [Geodetic and Topographic Institute] under the direction of comrade J. Zoula. Evaluations were made on six pairs of photographs of the 1:25,000 map. The scale of the photographs made in 1953 is about 1:23,000; the scale of the photographs made in 1959 for a 1:10,000 map is about 1:18,000. After receiving instructions concerning the procedure, the workers evaluated two pairs of photographs on an evaluating machine in one shift. The machine coordinates of about 15 points were determined for one pair of photographs on the average.

The measured matching points on photographs for the 1:10,000 map are less likely to be identified on the photographs for the 1:25,000 map. The identification would be easier if the proposed procedure were kept. In selecting matching points in the projected areas of matching points on photographs for both the 1:25,000 map and the 1:10,000 map, observing the photographs of both aerial observations at the same time, we shall probably be able to select a sufficient number of clearly identifiable points on both sets of photographs.

During the tests, efforts were made to identify measured matching points for the 1:10,000 map on photographs for the 1:25,000 map. The tests showed that such a procedure is difficult, but at the same time it was proved that is possible to identify those matching points in the proximity of previously-measured matching points; and therefore that it

is possible to make further use of photogrammetric bases for the 1:25,000 map. Only eight of the measured points could be identified on photographs of both scales. The accuracy of their photogrammetric determination from photographs for the 1:25,000 map is shown in Table II.

TABLE LI (Left side)

Point number	Set of 2 photographs	Photogrammetrically-determined elevation Z_f	Geodetically-determined elevation Z_g	Difference $Z_g - Z_f$ +	Difference $Z_g - Z_f$ -	Transformed photogrammetric coordinates Y_f	Transformed photogrammetric coordinates X_f
581/3	8088-89	398.55	397.99		0.56	480,889.30	531,702.73
579	8088-89	419.65	418.80		0.85	479,097.42	532,871.60
530/3	8075-76	497.65	496.64		1.01	480,184.28	536,322.23
556	8076-77	470.55	470.65	0.10		481,833,42	535,071.20
556/3	8089-90	437.50	438.50	1.00		481,615.43	534,294.81
582/3	8088-89	399.20	399.25	0.05		481,867.65	531,641.89
581/3	8088-89	399.00	397.99		1.01	480,889.15	531,701.15
581/2	8088-89	394.60	395.84	1.24		480,489.68	533,859.81

FOR OFFICIAL USE ONLY

TABLE II (Right side)

Point number	Geodetic coordinates Y_g	X_g	Difference $Y_g - Y_f$ +	$Y_g - Y_f$ -	$X_g - X_f$ +	$X_g - X_f$ -	Position error
581/3	480,889.3	531,701.2	0.00			1.53	1.53
579	479,096.1	532,873.3		1.32	1.70		2.15
530/3	480,184.3	536,321.3	0.02			0.93	0.93
556	481,835.0	535,070.3	1.58			0.90	1.82
556/3	481,614.6	534,293.2		0.83		1.61	1.81
582/3	481,866.5	531,642.8		1.15	0.91		1.46
581/3	480,889.3	531,701.2	0.15		0.05		0.16
581/2	480,487.8	533,860.2		1.88	0.39		1.92

(According to Table II, the average elevation error of points determined photogrammetrically from the photographs for the 1:25,000 map is ± 0.84 m, and the average position error ± 1.59 m. It is probable that the accuracy of the photogrammetric determination would have been higher, if according to the proposed procedure it had been possible to select clearly identifiable matching points and to observe the photographs of both aerial surveys at the same time.)

END